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Procedia Engineering 38 (2012) 607 – 612

Procedia Engineering

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International Conference on Modeling, Optimization and Computing (ICMOC 2012)

Performance Evaluation of MIMO-OFDM Modeling for UMTS-Long Term Evolution Downlink System

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Abstract

As the demand for the Mobile Communication Services increase, the research towards high data rate for meeting higher demands also increases. This made the path for the evolution towards the fourth generation Mobile Communication named as E-UTRA/UTRAN Long Term Evolution (LTE) given by 3GPP. In this paper LTE downlink performance is analyzed. Synchronization Error which degrades the OFDM System Performance is reduced by Synchronization Algorithm. This technique is implemented in Multiple Input Multiple Output (MIMO) to boost the capacity of the channel for to achieve higher data rate.

*Keywords:*LTE; OFDM; MIMO; 3GPP; Synchronization Error.

1.Introduction

Today the demand for high data rate increase as the need for mobile data service is rapidly increasing. This motivated the 3GPP (Third Generation Partnership Project) organization, an international collaboration project founded in December 1998. 3GPP is dedicated to deliver globally acceptable and applicable mobile phone specifications for high data rate. UMTS (Universal Mobile Telecommunication Service) is a 3G Mobile Communication. Now 3GPP is working towards Fourth Generation (4G) that is to improve UMTS to cope with future requirements.

The objective of UMTS LTE introduced in 3GPP release8 is to achieve high data rate, packet optimized radio access technology, low latency, improved spectral efficiency [2]. The specification

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doi:10.1016/j.proeng.2012.06.075

related to LTE is also referred as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN) and commonly known as LTE. Main requirements for designing an LTE system are given by 3GPP [9].

In LTE OFDMA with Cyclic Prefix is used in Downlink. 3GPP selected OFDM because of its robustness to multipath fading and spectral efficiency. The signal is transmitted through MIMO antenna to improve radio link communication. MIMO channel undergoes frequency selective, in MIMO-OFDM this frequency selective MIMO channel can be transformed into a set of parallel frequency flat MIMO channels, and thus the receiver complexity is decreased [3].

1. OFDM

OFDM is becoming the preferred modulation scheme for both high bit rate and broadband since it has good spectral efficiency and robustness against multipath interference. In transmitter section of OFDM the serial data stream is first converted into parallel dataset. IFFT is used to convert the frequency domain dataset into time domain samples [5]. In the receiver section OFDM signal is split from a serial data stream to parallel dataset. The FFT is used to convert the time domain samples back to frequency domain in which the magnitude of the frequency domain components corresponds to the original data.

The block diagram of the OFDM modulator and demodulator is shown in Fig. 3. With a symbol rate of $1/T_S$ the serial data stream is mapped to data symbols employing phase and amplitude modulation scheme. The resulting symbol stream is the demultiplexed N data symbols given as X_0 to X_{N-1}. The parallel symbol duration is N times longer than the serial symbol duration Ts, thus the parallel data symbol rate is $1/NT_s$. The IFFT of the data symbol vector is computed and the OFDM symbol is constituted with the coefficients $X_0, X_1,.., X_{N-1}$. The time domain samples of the OFDM symbol Ts are transmitted sequentially at a symbol rate of $1/T_S$ over the channel.

In the transmitter a carrier OFDM symbol of $M = N/2$ for a QPSK mapped symbol sequence {d0, d1, d2…} is given by,

$$X(t)=Re\sum_{K=0}^{\frac{N}{2}} d_k \exp\left(\frac{j2\pi kt}{T}\right) for\ 0 \le t \le T \tag{1}$$

Equation (3) gives the discrete time OFDM symbol when the given OFDM signal is sampled at $t = nTs$

$$X(n) = \frac{1}{N}\sum_{K=0}^{N-1} d_k \exp\left(\frac{j2\pi Kt}{T}\right), for\ 0 \le n \le N-1 \tag{2}$$

At the receiver section the N carrier OFDM signal gives the detection statistic for the QPSK mapped symbol sequences which is given as,

$$d_K = \int_0^T X(t) \exp\left(\frac{-j2\pi Kt}{T}\right) dt, for\ 0 \le K \le N-1 \tag{3}$$

By comparing $\{d_o, d_1, ..., d_{N-1}\}$ against the appropriate thresholds the QPSK mapped symbols can be obtained. By sampling OFDM symbol at a rate of $t = T$ the equation becomes,

$$d_K = \sum_{K=0}^{N-1} x(n) \exp\left(\frac{-j2\pi Kn}{N}\right), for\ 0 \le K \le N-1 \tag{5}$$

2. Synchronization Algorithm

To align the modulator and demodulator of the local oscillator and to identify the start of the OFDM symbol the time and frequency should be synchronized properly [4]. Offsets leads to synchronization error in the system which leads to loss of orthogonality which make path for interference. One of the proposed methods for reducing the synchronization error is Joint Weighted Least Square algorithm.

The phase difference of pilot α_j on two consecutive OFDM symbol is,

$$\theta_j = < (Y_{i,\alpha_j}, Y_{i-1,\alpha_j}) \tag{6}$$

Where θ_j is the phase difference and Y_i is the demodulated OFDM samples. As the phase difference is estimated the phase offset is obtained as,

$$\theta_j = 2\pi \frac{N+N_g}{N}\left(E_{\alpha j} + f_c T_s\right)\delta + e_j \tag{7}$$

Where N is the useful samples, N_g is the guard interval, $E\alpha_j$ is the energy of the pilot, f_C is the carrier frequency, Ts is the sample time, δ is the JWLS algorithm reduced to estimate for one oscillator offset.

$$\hat{\delta} = \frac{\sum_{j=0}^{J-1} W_j \theta_j (E\alpha_j + f_c T)}{(2\pi \frac{N+N_g}{N}) \sum_{j=0}^{J-1} W_j (E\alpha_j + f_c T)} \tag{8}$$

Where $\hat{\delta}$ is the estimated SCO after obtaining the phase offset for OFDM pilots of same symbol. The estimated CFO is compensated by Inverse Carrier Frequency Offset (ICFO). Linear interpolation is used to compensate the SCO. The sample data can be obtained from the first order interpolation.

3. MIMO-OFDM

In MIMO system the spectral efficiency is increased for a given transmit power. Spectral efficiency is the total number of information bits per second per hertz transmitted from one array to the other. Depending upon the channel condition MIMO is split into spatial diversity and Transmit diversity. Since it has several transmitter and receiver antenna it exploits spatial diversity. Thus the capacity is increased by introducing additional spatial channel exploited by using space-time coding [1].

MIMO present two modes of operation, closed-loop and open-loop. Open-loop MIMO knows the channel state information (CSI) at the receiver side, but closed-loop knows the CSI at receiver side. User Equipment report CSI to Base Station so it can be used for next transmission, provide channel variation because of environmental changes and mobile speed. Space-Time Block Coding (STBC) and Space-Frequency Block Coding (SFBC) are examples of open-loop Transmit Diversity. Alamouti code is the commonly known code for two antennas at the transmitter [6].

4. LTE Downlink

LTE downlink air interface consists of physical signals and physical channels which are generated by LTE physical layer. The data from higher layers including scheduling, control, and user payloads are carried by physical channels [7]. Physical signals are used for cell identification, system synchronization and radio channel estimation.

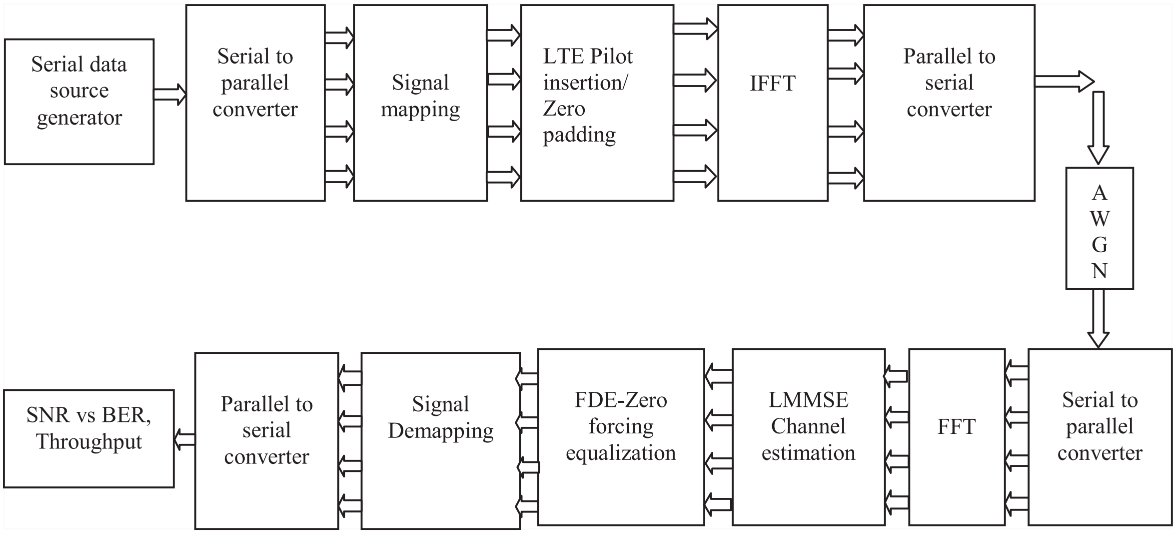


Figure 1. Block diagram of OFDM UMTS-LTE system

In fig.1.the signal is mapped using QPSK modulation. The transmitted Signal spectrum width is less than the sampling rate of OFDM modulator, thus zero padding is made for unused frequency bands. To generate time version of transmitted signal IFFT. In front of every transmitted OFDM symbols Cyclic Prefix is inserted to avoid interference [8]. In the receiver the data is serial to parallel converted. The time domain is converted into frequency domain using FFT. Frequency-Domain Equalizer is implemented for every sub-carrier in the form of MMSE equalizer for channel estimation. Then the signal is given to QPSK demodulator.

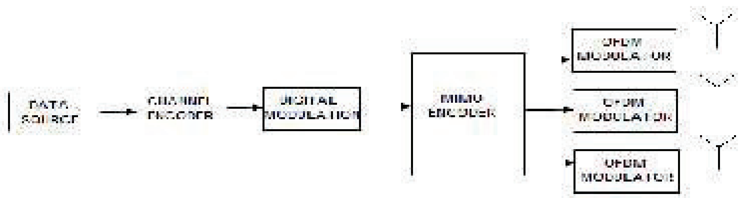


Figure.2. Block Diagram of an OFDM Transceiver

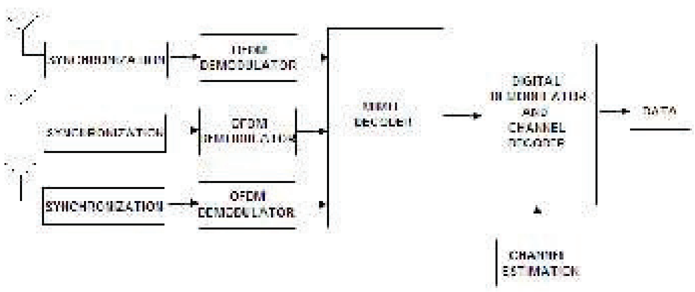


Figure.3. Block Diagram of MIMO-OFDM Receiver

In case of channel estimation of MIMO system, with N transmitters and M receivers, there are N*M channels to be estimated. Simultaneously the signals are transmitted from all transmitters, thus the superposition of all transmitted signals are received. The transmitted signals are distorted by the channel. In the receiver section except the first transmitter signal all other signals are considered as interference by the first receiver. Thus a pilot tone is inserted in the sub-carrier so that other transmitter doesn't send anything in that sub-carrier. As shown in fig.2.

5. Results Obtained

Using MATLAB simulation the obtained output used to evaluate the performance of LTE system. Fig.1. shows the Transmitted OFDM Spectrum. In fig.2.the channel is estimated for both AWGN and Rayleigh channel for theoretical and simulated outputs, in which AWGN holds good for MIMO communication. Fig.3.gives the performance of 2*2 MIMO-OFDM for different users. From fig.4 shows the LTE system performance for different users and fig.5 shows the throughput analysis for the LTE system for N users.

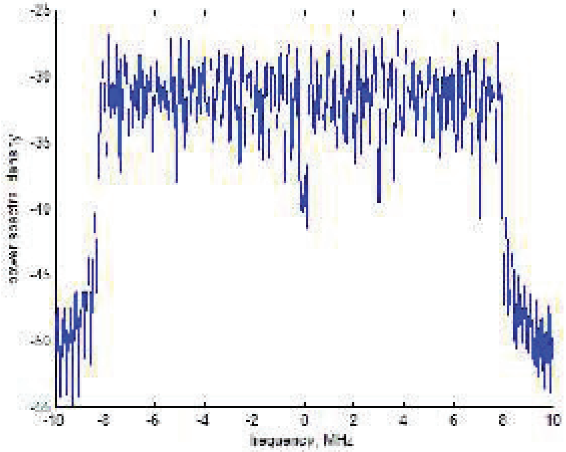


Figure.4. Transmitted OFDM Spectrum

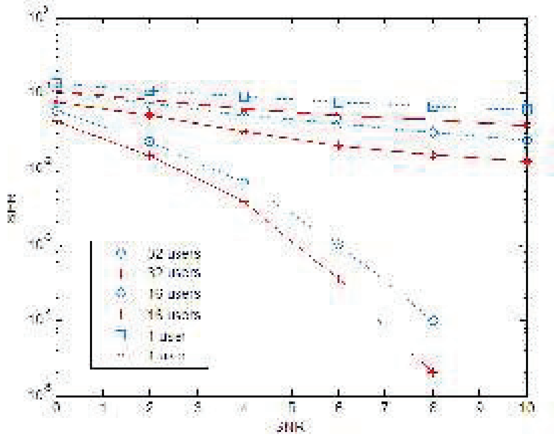


Figure.6. MIMO-OFDM for Different Users

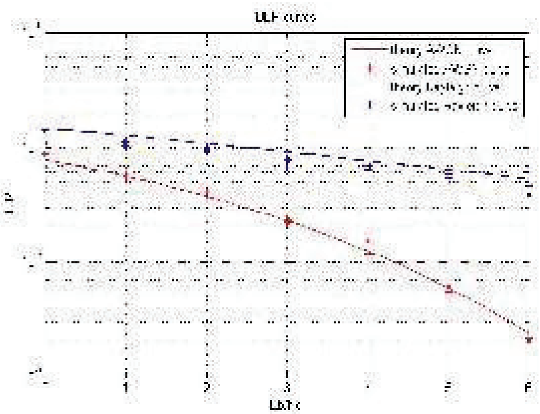


Figure.5. BER analysis of AWGN and Rayleigh channel

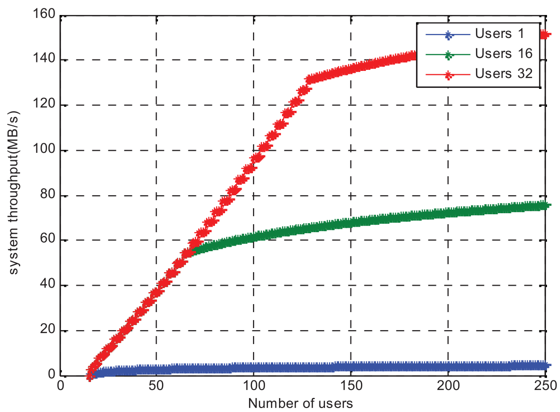


Figure.7. LTE system for different users

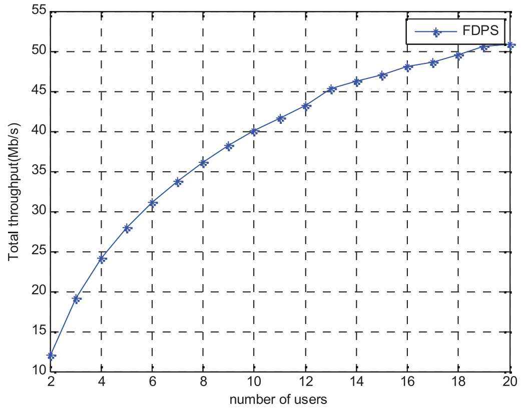
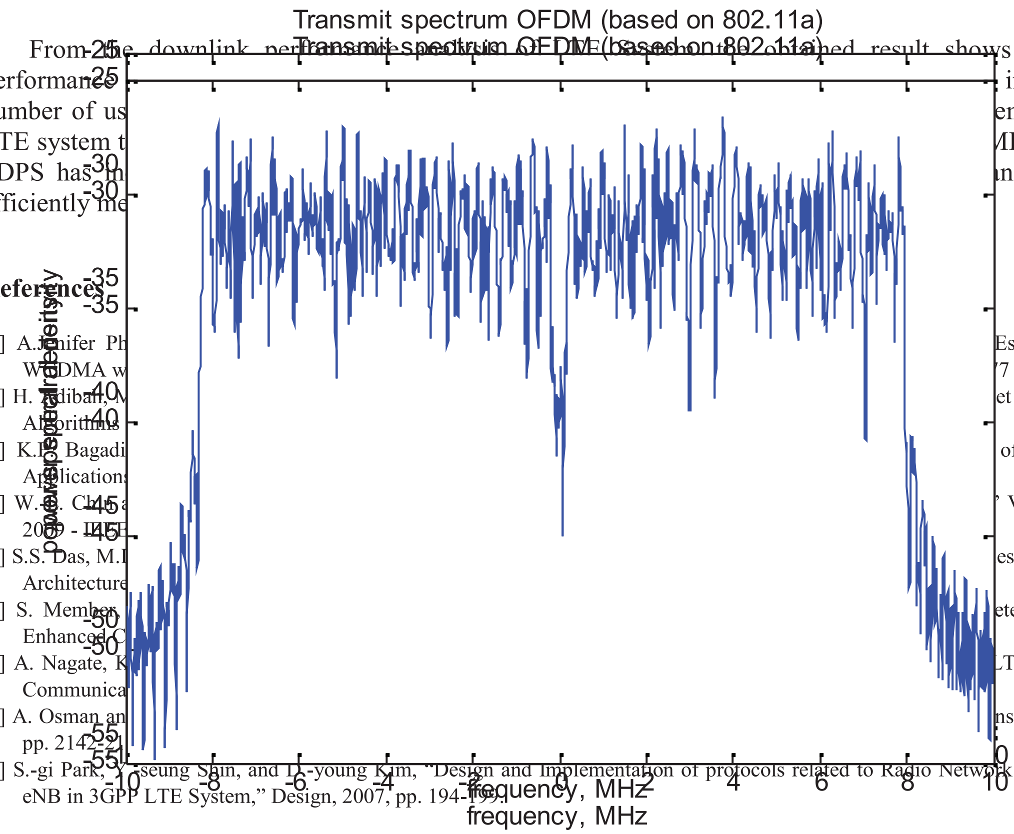


Figure.8. LTE MIMO with FDPS

6. Conclusion



From the downlink per[illegible] result shows that the performance [illegible] increasing number of us[illegible]emands. In LTE system t[illegible]MIMO with FDPS has m[illegible]nce which efficiently me[illegible]

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